AGROFORESTRY COMPONENT IN FORMATION AND FUNCTIONING OF CURRENT AGRICULTURAL LANDSCAPES

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Abstract

The purpose of this research is to justify the agroforestry component in the formation and functioning of current agricultural landscapes. We analyzed the structure of agro-landscapes within of natural zones of Ukraine. Our results suggest that 52% of the territory belongs to the state of destruction, and the proportions of unstable, medium-stable and stable landscapes are 12.8% and 4.0%, respectively. The agro-landscapes with ecological balance and sustained fertility growth occupy only 4.0% of the total area. We have assessed the ecological stabilization of agro-landscapes in the zonal aspect. The ecological stability factor for the entire territory is 0.38. The values of an environmental sustainability factor calculated using optimization of the structure of agro-landscapes for Steppe, Forest-Steppe and Polissia are 0.41; 0.45 and 0.61 respectively. This indicator for the whole territory is 0.47. Achieving favorable environmental conditions depends on the use of the optimal composition of land uses in various elements of agro-landscape.

Keywords: agro-landscape; protective stand; natural and anthropogenic impacts; environmental sustainability factor.

Introduction

Scientific principles of forest amelioration at the landscape level were developed at the turn of the nineteenth and twentieth centuries based on the fundamental research of domestic and foreign scientists including the founder of the doctrine of forest amelioration V. Dokuchaev and his followers – G. Vysotskyi, L. Berg, Ye. Pavlovskyi (Vysotskyi 1950; Gladun et al. 2007). The large-scale experiments using different systems of protective forest stands were conducted by "Special Expedition" under the leadership of V. Dokuchaev in 1897. Dokuchaev's doctrine of the application of forest amelioration at the landscape level inspired investigations of anthropogenic-modified landscape complexes (Bayllovich 1938). One of the most important components of assessing the state of natural-territorial complexes is estimating the degree of their anthropogenic transformation. Anthropogenic transformation of a natural-territorial complex is the change in its structural and dynamic features as a result of functional use (Grodzinskyi and Shishchenko 1993). It is used to develop the system of ecological management of the region, to balance regional environmental policy, and to optimize the use of natural resources. This analysis reveals regional patterns of anthropogenic transformation of the territories, which allows classification and assessment of the degree of environmental stress as well as the development of the adequate measures for its improvement.

The purpose and tasks of the research

The purpose of this research is to justify the agroforestry component in the formation and functioning of current agricultural landscapes and to develop the scientific basis for the provision of the forest-melioration component of sustainable agro-landscapes. To achieve this goal, we set three research objectives. First, we substantiate landscape-ecological principles of application of forest amelioration on a zonal-regional basis. Second we determine the degree of violation of the ecological situation in the modern agro-landscapes. Finally we assess the resilience of agro-landscapes to anthropogenic impacts and develop the integral structure of the ecological framework for the agricultural landscapes.

Materials and methods

The theoretical and methodological basis of the research is a systematic approach to the study of the processes of conservation of agro-landscapes from the action of a complex of negative factors using forest plantations. We analyzed the current state and structure of agro-landscapes using the method of statistical generalization, comparison, analysis and synthesis. The parameters of the field-protection forest cover were justified using method of forming the ecological framework of agro-landscapes using the abstract-logical method (Gladun 2007).

The current state of agrolandscapes was analyzed using the methodology of optimal correlation of land (Grodzinskyi 1995), which is based on the ratio of destabilizing and ecologically stabilizing land uses (forests, meadows, pastures, orchards, riparian, water bodies).

To determine the degree of environmental degradation of current agrolandscapes of the regions of Ukraine, we conducted an assessment of their stability over the range of areas of arable land and ecologically stabilizing land uses according to the methodology of Postolov and Kryukova, (2010). We used land-use data by natural-climatic zones of Ukraine for 2014.

Optimization of the interaction of agricultural production and the environment was conducted taking into account the concept of "Ecological and economic balance" (Kochurov 1999) which implies solving of land-ecological problems by improving the structure of land use.

Results and discussion

The resilience of the agrolandscape to negative anthropogenic and natural impacts can be achieved using concept of ecological framework (Nikolaev 1992). This concept of ecological framework is similar to other concpets such as ecological network, nature conservation geosystem (Preobrazhensky and Alexandrova 1988), ecological texture of agro-landscape (Grodzinskyi 1995), territorial system of ecological stability of the landscape (Ruzicka and Miklos 1990), landscape-ecological skeleton (Rodin and Rodin 2003), the system of protected areas (Selyedets 1987) and others.The main rule in the adding new areas to agricultural use or in the optimization of established agricultural landscapes must be preserving and maintenance of in the effective state of natural elements of space-time environmental infrastructure (Kotlayrova et al. 2013). Prevention of adverse impacts on landscapes can be achieved through systematic structural measures, which will be discussed later.

We have developed a basic scheme of the ecological framework for a region, which may be the basis for ensuring the stability of the lands of current agro-landscapes (Figure 1).

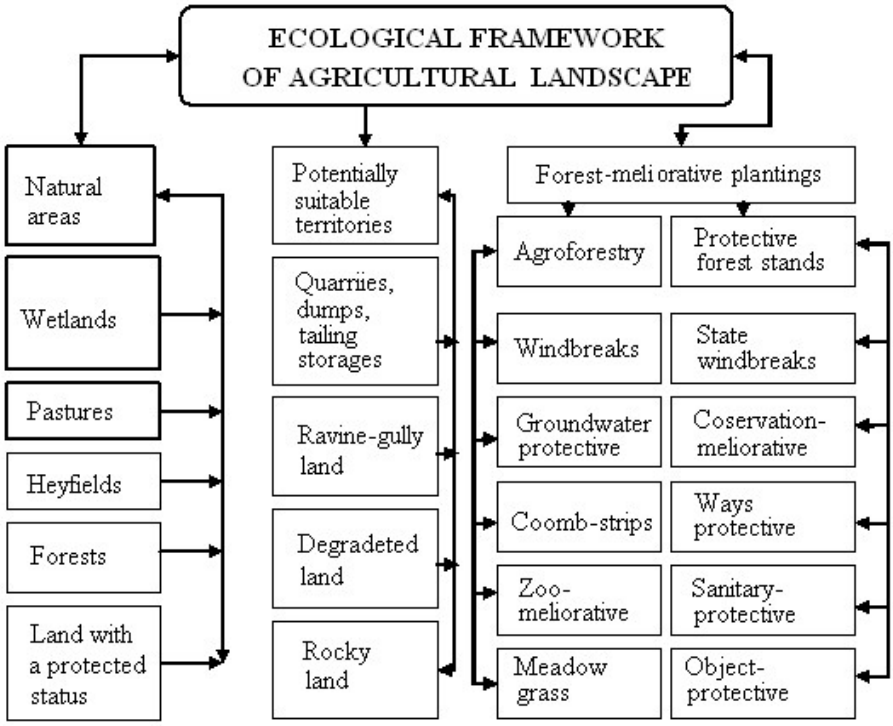

Figure 1: Scheme of the ecological framework of agro-landscape.

The choice of the elements of the ecological framework, as well as the placement of agricultural land, should be based on the principle of adaptability. All newly created elements of the ecological structure, such as forest strips, windbreaks, buffer strips of hayfields, pastures and perennial grasses, ponds, etc., should fit into the natural morphology of agro-landscapes. This fit is mainly determined by the features of the meso - and micro-topography (Yukhnovskyi 2003). In general, the regional structure of agro-landscapes must be adaptive-constructive in its content.

The optimal composition of land uses of the region depends on the adaptability of agricultural production while taking into account environmental factors.

To determine the degree of environmental degradation of current agro-landscapes, we conducted an assessment of their resilience at different levels arable lands, and ecologically stabilizing land uses. Our results indicate that 52% of the territory of Ukraine is assessed as being at the state of destruction. The landscapes assessed as unstable, average stability and resilient occupy 12%, 8% and 4% respectively. Agricultural landscapes with ecological balance with stable fertility growth occupy only 4% of Ukraine's territory.

The main reasons for the current state of landscape resilience are: a high level of cultivation of agricultural lands (over 80%), the spontaneity in changing land uses, the absence of national, regional and local soil conservation programs, the low level of financial support for soil erosion protection measures, and deficiencies in the implementation of land reform. The causes of increase in soil erosion processes are the violations of the organization of the territory, the decline of forest amelioration, the deterioration of the state of the windbreaks, the neglect of the basic rules of erosion-safe land use and the inadequate use of effective contouring-melioration erosion control measures in the agriculture.

To estimate the degree of ecological balance of agro-landscapes, we calculate the ratio of the main land uses: arable land – native pastures – forests. For Ukraine overall, this ratio should be equal to 1:1.6:3.6 (Sozinov et al. 1998). The observed ratio is 1:0.23:0.3, indicating a violation of the ecological balance in agro-landscapes. The ecological stability of the region is estimated using the of ecological stability factor (CES). The coefficient of ecological stability of agro-landscape is calculated using equation 1:

$$CES = \frac{\sum K \times S_i}{\sum S}, \qquad (1)$$

where K_i is the coefficient of ecological stability of land use *i*; S_i – area of *i*-th land use.

The region is considered environmentally unstable when CES is less than 0.33. When CES varies from 0.34 to 0.50, the region belongs to stable instability, when CES is in the range from 0.51 to 0.66, the region is beyond the average stability, and when CES exceeds 0.67, the region is environmentally stable.

The average value of CES calculated for the Steppe, Forest-Steppe and Polissia is 0.29, 0.36 and 0.55 respectively. For the whole territory of Ukraine, CES is 0.38. Optimal values of CES for the mentioned zones are calculated as 0.41; 0.45; 0.61 respectively and for whole Ukraine, it is 0.47.

The coefficient of anthropogenic impact (CAI) characterizes the adverse phenomena in agro-landscapes and reflects the zonal-regional particularities of land use. The coefficient of anthropogenic impact is calculated by the formula 2:

$$CAI = \frac{\sum P_i \times S_i}{\sum S}, \qquad (2)$$

where P_i – an anthropogenic impact on *i*-th land use in the agro-landscape; S_i – an area of *i*-th land use.

The values of CAI indicator calculated for the Steppe, Forest-Steppe and Polissia are 3.63; 3.50 and 3.06 respectively. The value of CAI for the territory of Ukraine is 3.44. The proposed changes to optimize the structure of the abovementioned zones are 3.34; 3.26; 2.93 respectively. In general, the CAI for Ukraine was calculated in 3.21.

The organizational basis for improving the management of forest meliorations should be the use of the principles of placing various categories of protective plantings on landscape-ecological and catchment basis. Landscape-ecological principles of the use of forest meliorations in current agro-landscapes include a number of measures of different content, but the basis is the optimization of the composition and the ratio of lands of agro-landscapes by removing from the warehouse arable land degraded and unproductive lands, the afforestation of rocky and damaged ravines steep slopes, sands and parts of riparian strips.

Conclusion

The analysis of the current structure of agro-landscapes found that 52% of the territory of Ukraine belongs to the state of destruction, and the proportion of unstable, medium-stable and stable territories is 12.8 and 4.0%, respectively. The agro-landscapes with ecological balance and sustained fertility growth occupy only 4.0% of the total area.

Estimation of the ecological stability of the territory showed that ecological stability factor for the Steppe, Forest-Steppe and Polissia zones is 0.29; 0.36 and 0.55 respectively. In general, for the territory of the country,, the CES reaches 0.38. As a result of optimization of the structure of agricultural lands CES can reach 0.41; 0.45; 0.61 for the climatic zones, respectively. It can reach the value of 0.47 for whole Ukraine.

The values of the coefficient of anthropogenic impact for the Steppe, Forest-steppe and Polissia zones are 3.63; 3.50 and 3.06 respectively. For the territory of Ukraine, CAI reaches 3.44. We have calculated optimal values of CAI for the optimized structure of the land use of agricultural landscapes. The values of CAI for the climatic zones are determined as 3.34; 3.26 and 2.93, respectively, and for the whole territory of Ukraine it is determined as 3.21.

We have developed the basic scheme of the ecological framework of the territory, which may be the basis for ensuring the stability of the lands of current agro-landscapes.

The application of the landscape-ecological methodology of forest amelioration enabled to substantiate the principles of the formation of a spatial geometry of current agro-landscapes, in which the predominant and system-forming element of land protection is a combination of field-protection afforestation and agroforestry.

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